What is claimed is:

1 1.   A user interface device to manipulate a position of a cursor

2 on a screen display in an electronic apparatus, comprising:

3   a tracking element actuatable to track the position of said

4 cursor on said screen display;

5   at least one motor interconnected to said tracking element and

6 having a position encoder connected thereto, each said position

7 encoder generating a motor position signal indicative of the

8 position of a respective motor;

9   a controller receiving cursor position information from said

10 electronic apparatus and motor position information from a

11 respective encoder;

12   a store of force-position information accessible to said

13 controller, said controller accessing said store of force-position

14 information in response to at least one of said cursor position

15 information and said motor position signal to generate, using said

16 at least one motor, a positive or negative force in said tracking

17 element as a function of a position of said cursor on said screen

18 display.

19 2.   The user interface device of claim 1 wherein said tracking

20 element is a sphere interfaced to said at least one motor by at

21 least two sets of wheels contacting said sphere and said at least

22 two sets of wheels are aligned on mutually orthogonal axes.

23   3.   The user interface device of claim 2 wherein each of said at

24   least two sets of wheels comprises a hub about which a pair of

25   frames is disposed and each of said pair of frames includes

26   gripping members staggered in a manner so that there is always a

27   gripping member in contact with said sphere.

28   4.   The user interface device of claim 1 wherein said at least one

29   motor comprises a plurality of motors and each of said plurality of

30   motors has an associated complementary motor connected in series.

31   5.   The user interface device of claim 1 wherein said at least one

32   motor comprises a plurality of motors and each of said plurality of

33   motors has an associated complementary bearing.

34   6.   The user interface device of claim 1 wherein said at least one

35   motor comprises a plurality of motors each interconnected to said

36   tracking element by at least one set of wheels aligned on mutually

37   orthogonal axes and configured to sense or impart motion of the

38   tracking element on a respective axis.

39   7.   The user interface device of claim 6 wherein said plurality of

40   motors each interconnected to said tracking element by at least one

41   set of wheels aligned on mutually orthogonal axes are configured to

42   sense or impart motion of the tracking element on mutually

43   orthogonally disposed x and y-axes.

44   8.   The user interface device of claim 7 further including at

45   least one set of wheels configured to sense or impart motion of the

46   tracking element on a z-axis orthogonally disposed with respect to

47   said x and y-axes.

48   9.   A method of generating tactile responsiveness in a user

49   interface device having a tracking element manipulating a position

50   of a displayed element on a display screen of an electronic device,

51   said method comprising the steps of:

52   positioning a plurality of drive/position assemblies along

53   mutually orthogonal axes with respect to said tracking element,

54   each of said plurality of drive/position assemblies including a

55   motor and an associated encoder to drive and sense position of said

56   tracking element;

57   interfacing said user interface device to said display screen

58   via a controller that receives information from said associated

59   encoder of each of said plurality of drive/position assemblies and

60   from said electronic device to track movement of said tracking

61   element and the position on said display screen of said displayed

62   element;

63   storing force-position relation information, accessible to

64   said controller, as a function of the position on the display

65   . screen of the displayed element; and

66   accessing said force-position information via said controller

67   and generating a signal to each of said plurality of drive/position

68   assemblies to effect a positive or negative force to respectively

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69   assist or resist motion of said tracking element depending upon the

70   position of said displayed element on said display screen.

71   10.   The method of claim 9 wherein said step of positioning a

72   plurality of drive/position assemblies further includes positioning

73   a corresponding plurality of complementary slave assemblies along

74   corresponding mutually orthogonal axes, each of said complementary

75   slave assemblies being electrically connected in series with a

76   respective one of said plurality of drive/position assemblies.

77   11.   The method of claim 9 wherein the step of interfacing said

78   user interface device to said display screen via said controller

79   includes interconnecting said electronic device to said controller

80   to send and receive information about the position of the displayed

81   element on said display screen between said electronic device and

82   said controller, and interconnecting said plurality of

83   drive/position assemblies to said controller to send said signal to

84   each of said plurality of drive/position assemblies to effect said

85   positive or negative force to respectively assist or resist motion

86   of said tracking element depending upon the position of said

87   displayed element on said display screen.

88   12.   A user interface device having tactile feedback capabilities,

89   comprising:

90   an actuatable member for imparting a tactile feedback to a

91   user of said user interface device;

92   a motor interconnected to said actuatable member;

93   a position encoder in communication with said motor, said
94   position encoder providing position information of said motor;

95   a controller receiving said position information from at least
96   said position encoder;

97   a store of force-position relation information accessible to
98   said controller, said controller outputting at least one force
99   value corresponding to said position information in accordance with
100   said store of force-position relation information; and

101   a drive signal source generating a drive signal to said motor
102   in accordance with said at least one force value, said drive signal
103   causing a force in said motor to provide said tactile feedback to
104   said actuatable member to assist or resist motion of said
105   actuatable member.

106   13. The user interface device of claim 12 further including a
107   counter receiving said position information of said motor and
108   providing a count to said controller, said controller outputting a
109   force value corresponding to said position information in
110   accordance with said store of force-position relation information.

111   14. The user interface device of claim 13 wherein said force value
112   is a digital force value and further including a digital to analog
113   converter receiving said digital force value and converting said
114   digital force value to an analog force signal.

115   15.   The user interface device of claim 14 further including a

116   power amplifier receiving said analog force signal and generating

117   said drive signal to said motor in accordance with said at least

118   one force value, said drive signal being proportional to said

119   analog force signal.

120   16.   The actuator of claim 12 wherein said controller is a

121   microprocessor receiving said position information on at least one

122   port thereof.

123   17.   The actuator of claim 16 wherein said microprocessor includes

124   resident erasable programmable read only memory which is used for

125   said store of force-position relation information.

126   18.   The actuator of claim 12 wherein said drive signal source is

127   a current source including a power amplifier and said drive signal

128   is a current provided by said power amplifier.